

The effects of irrigation on past and future temperatures in the California Central Valley

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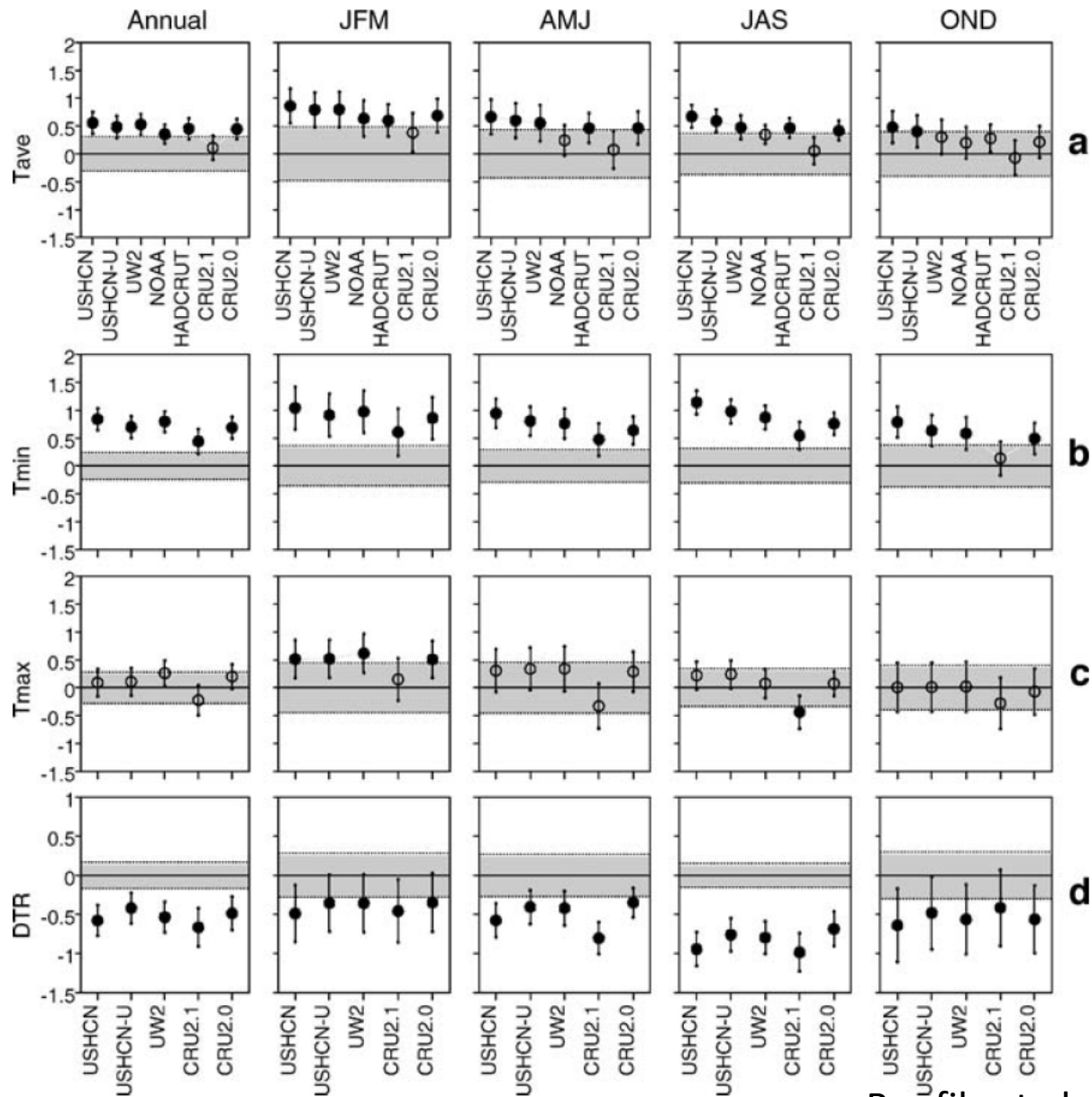
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Celine Bonfils

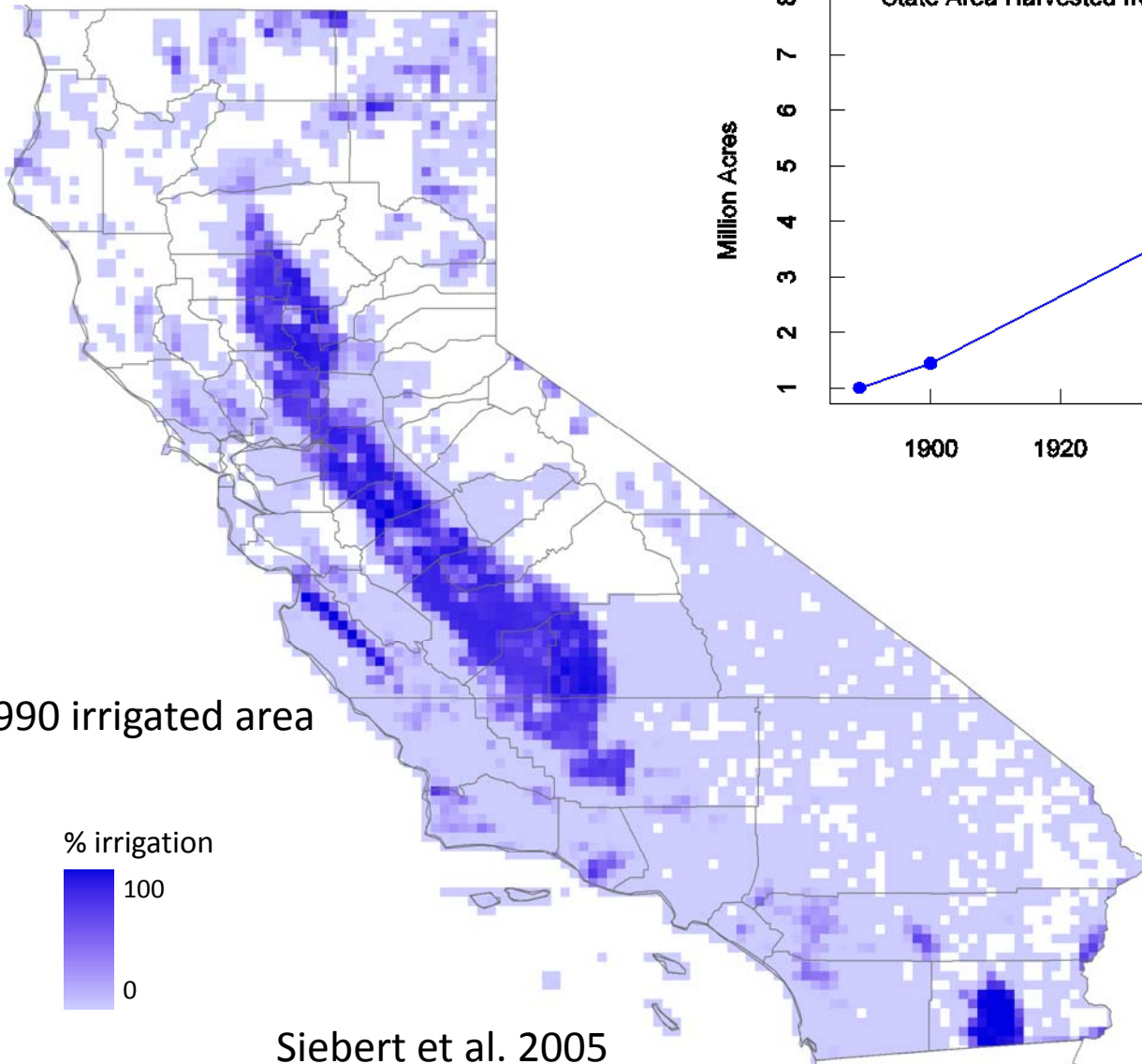
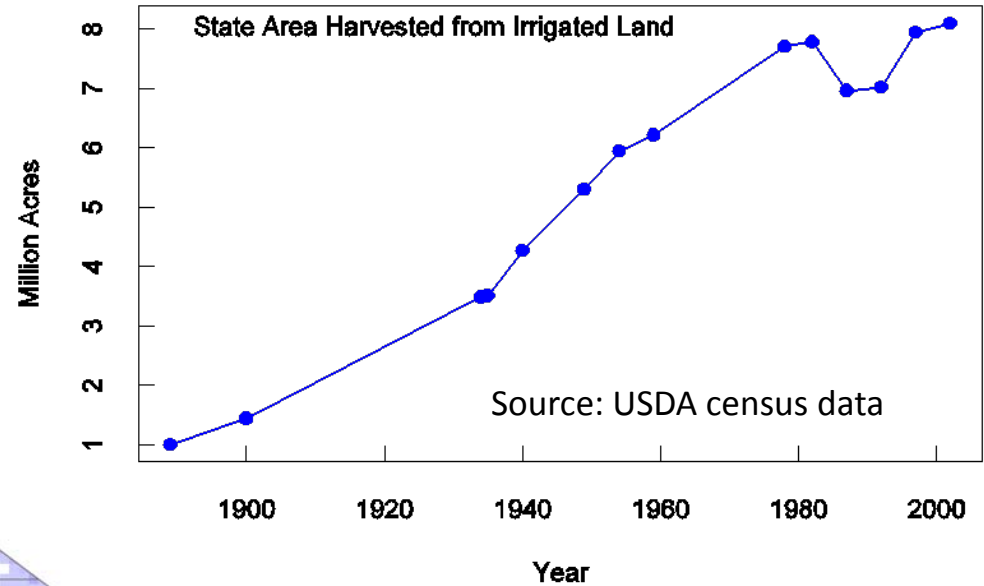
cbonfils@llnl.gov

An inconsistent record of warming in California?

Temperature trends, 1915-2000 ($^{\circ}\text{C}$ per 50yr)

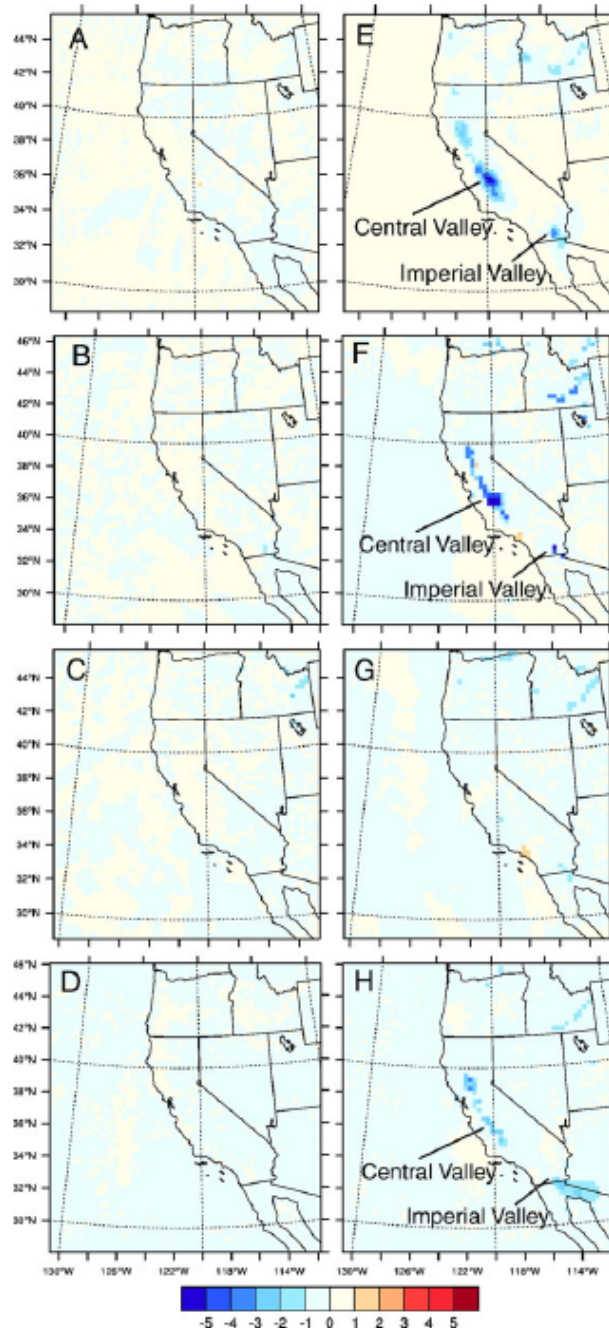


Irrigation in California



How much has irrigation influenced climate?: models

Temperature difference between model run with and without irrigation for January (left) and August (right)



Model:

RSM

RegCM3

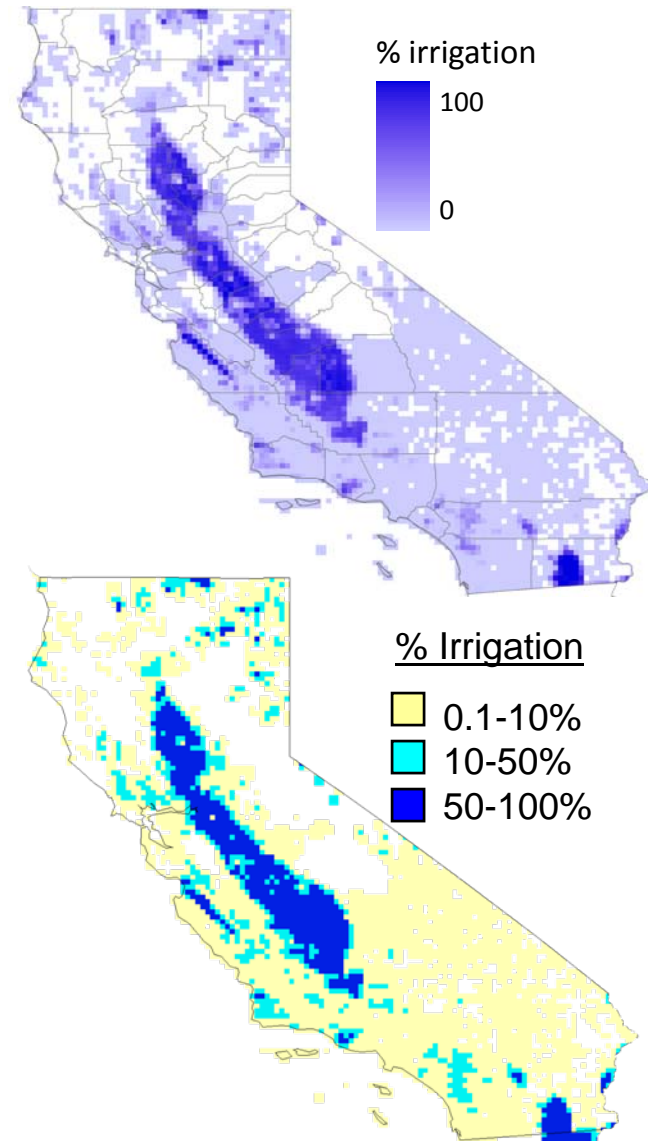
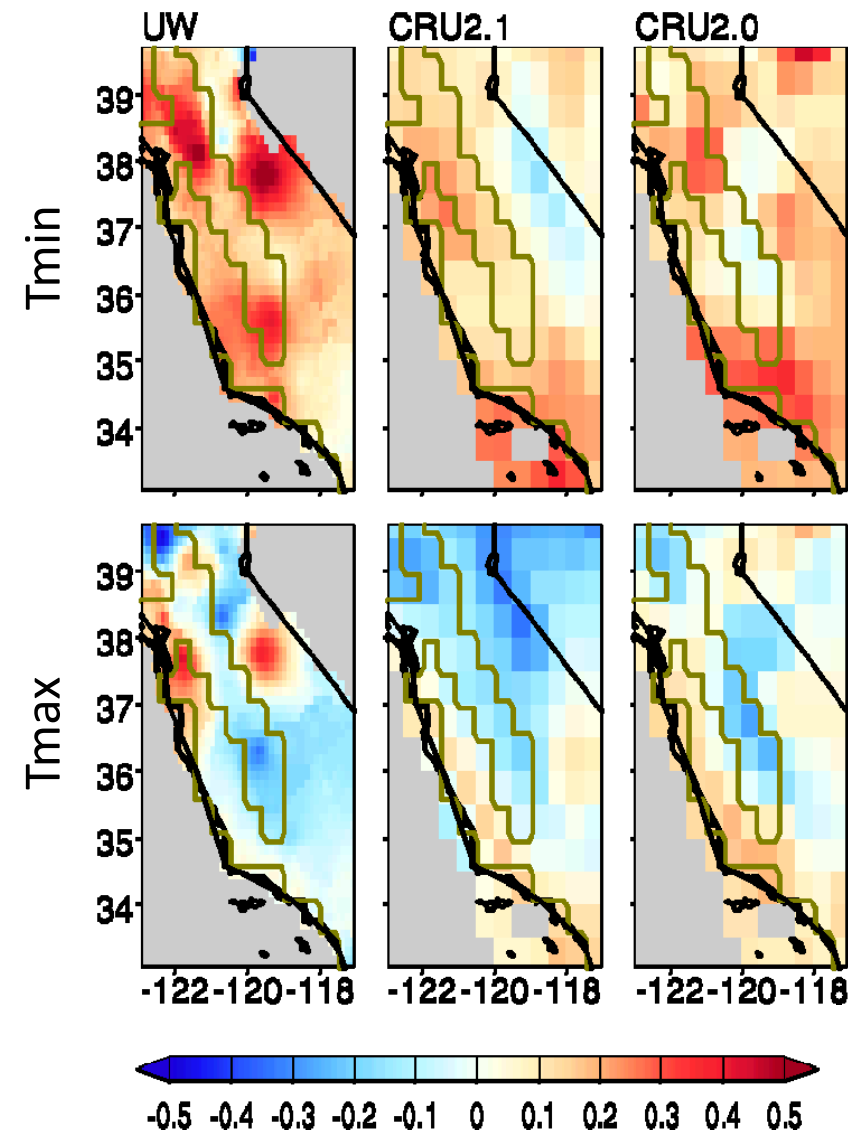
MM5-CLM3

DRCM

Kueppers et al. 2008, *GPC*

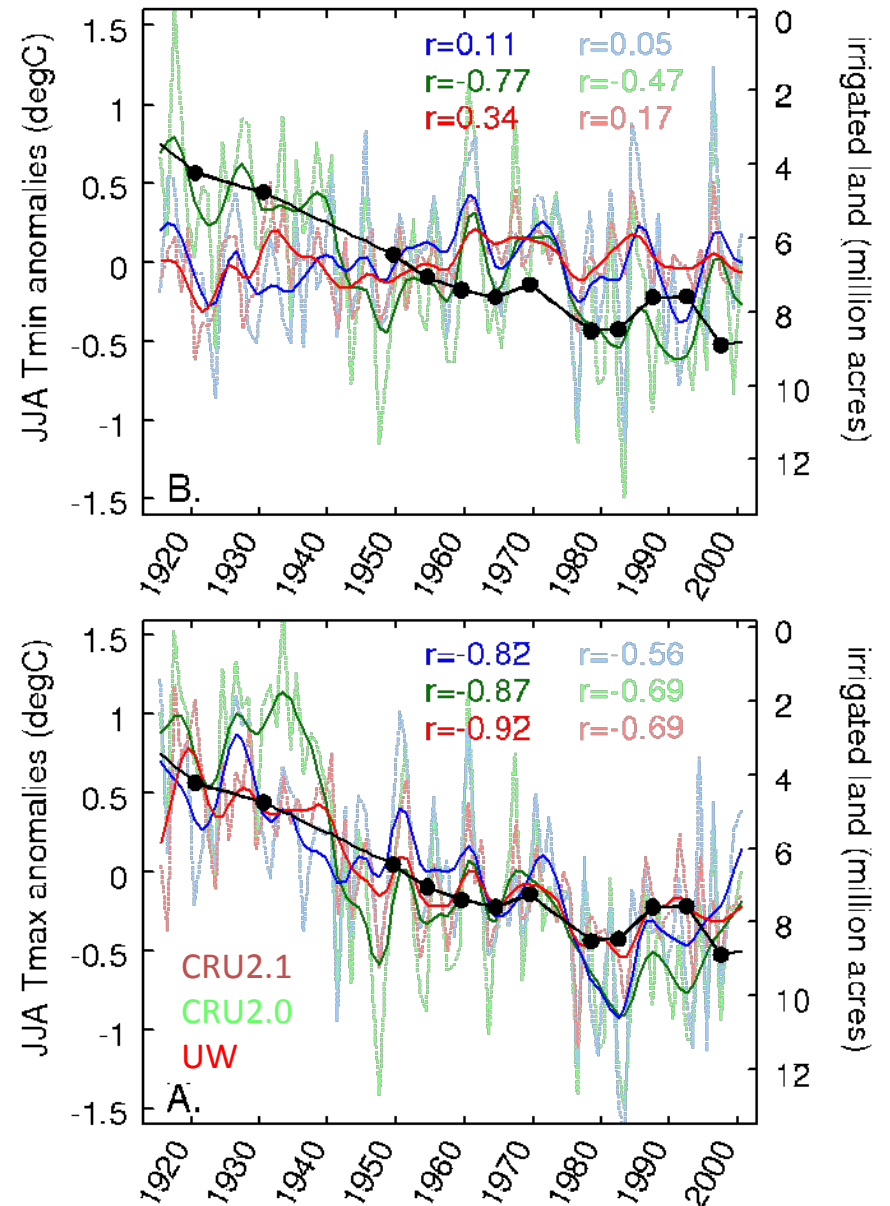
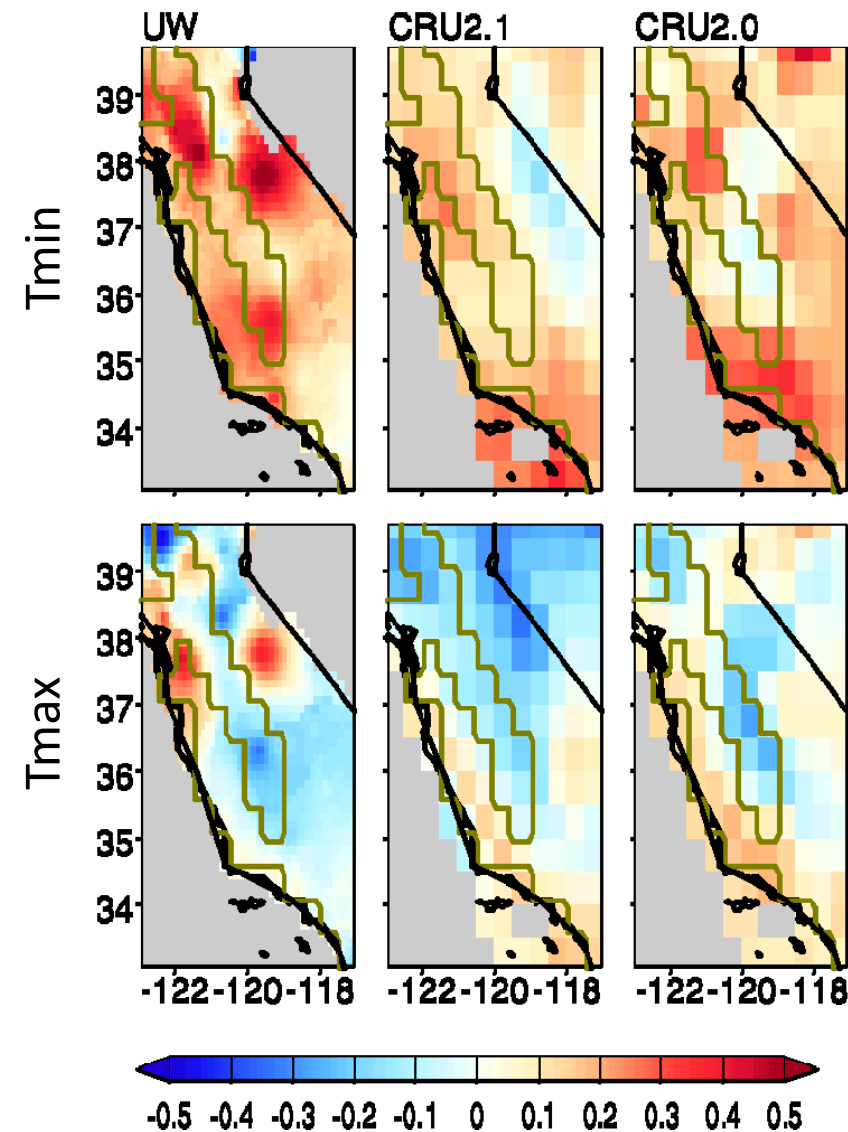
How much has irrigation influenced climate?: observations

1915-2000 trends ($^{\circ}\text{C decade}^{-1}$)



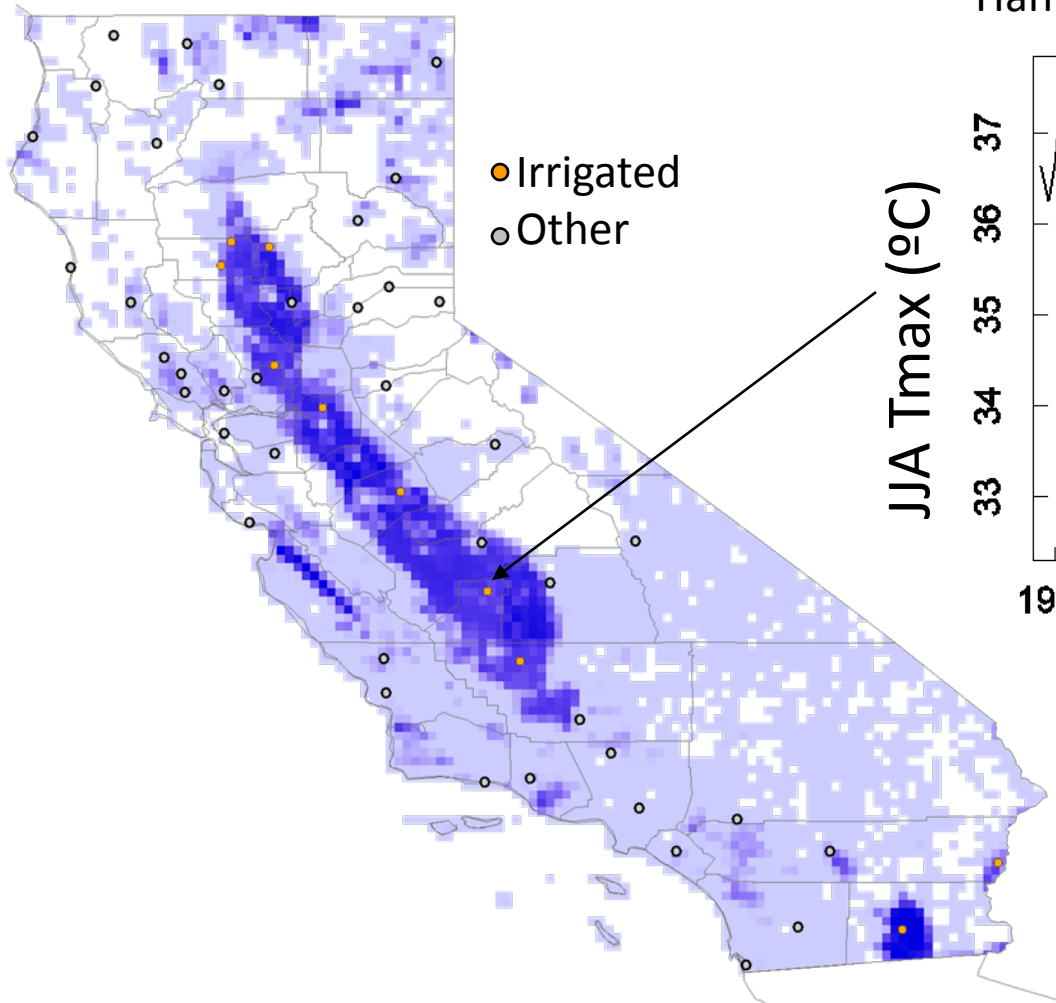
How much has irrigation influenced climate?: observations

1915-2000 trends ($^{\circ}\text{C decade}^{-1}$)

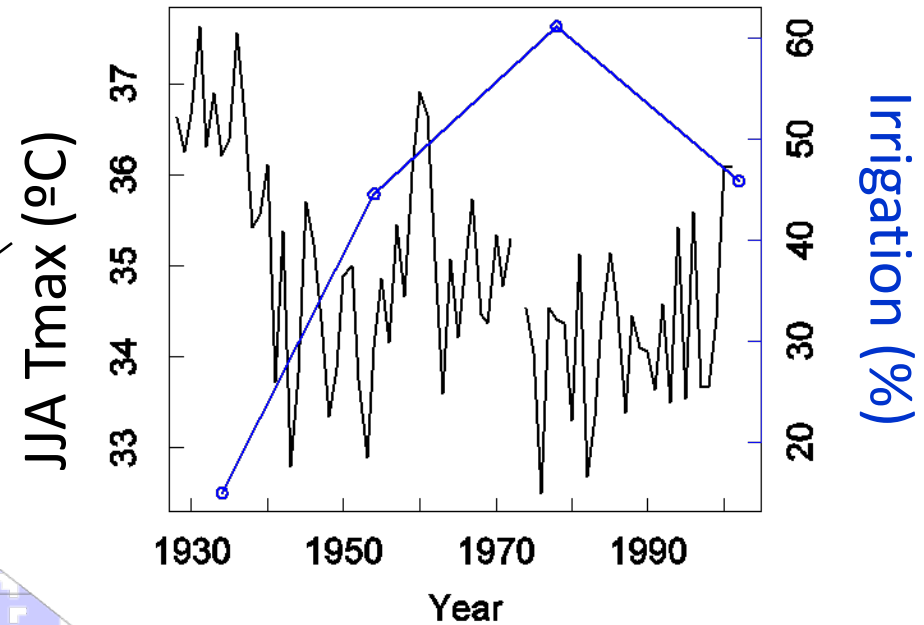


How much has irrigation influenced climate?: observations

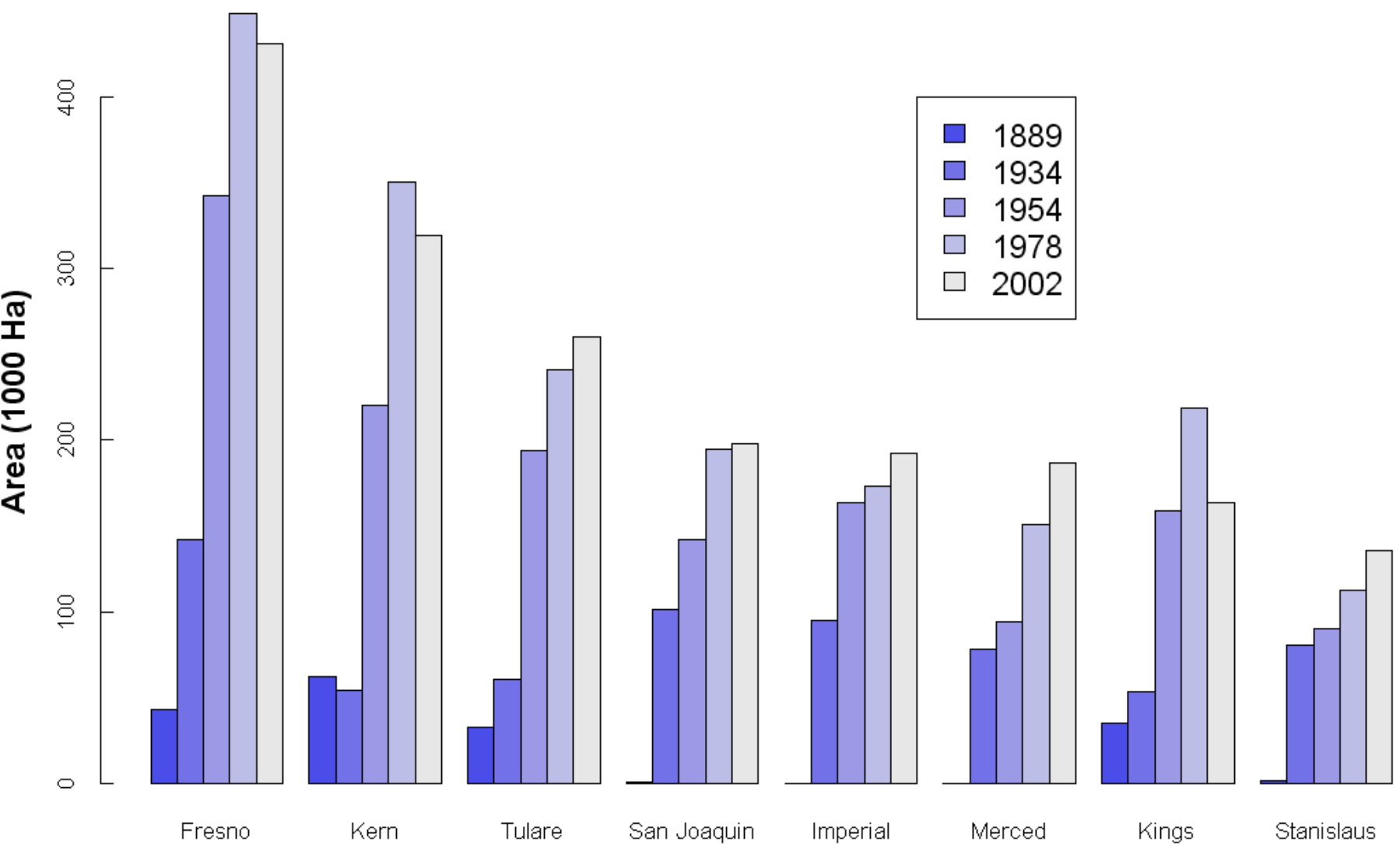
US Historical Climatology Network
(USHCN) Sites



Hanford station, Kings County

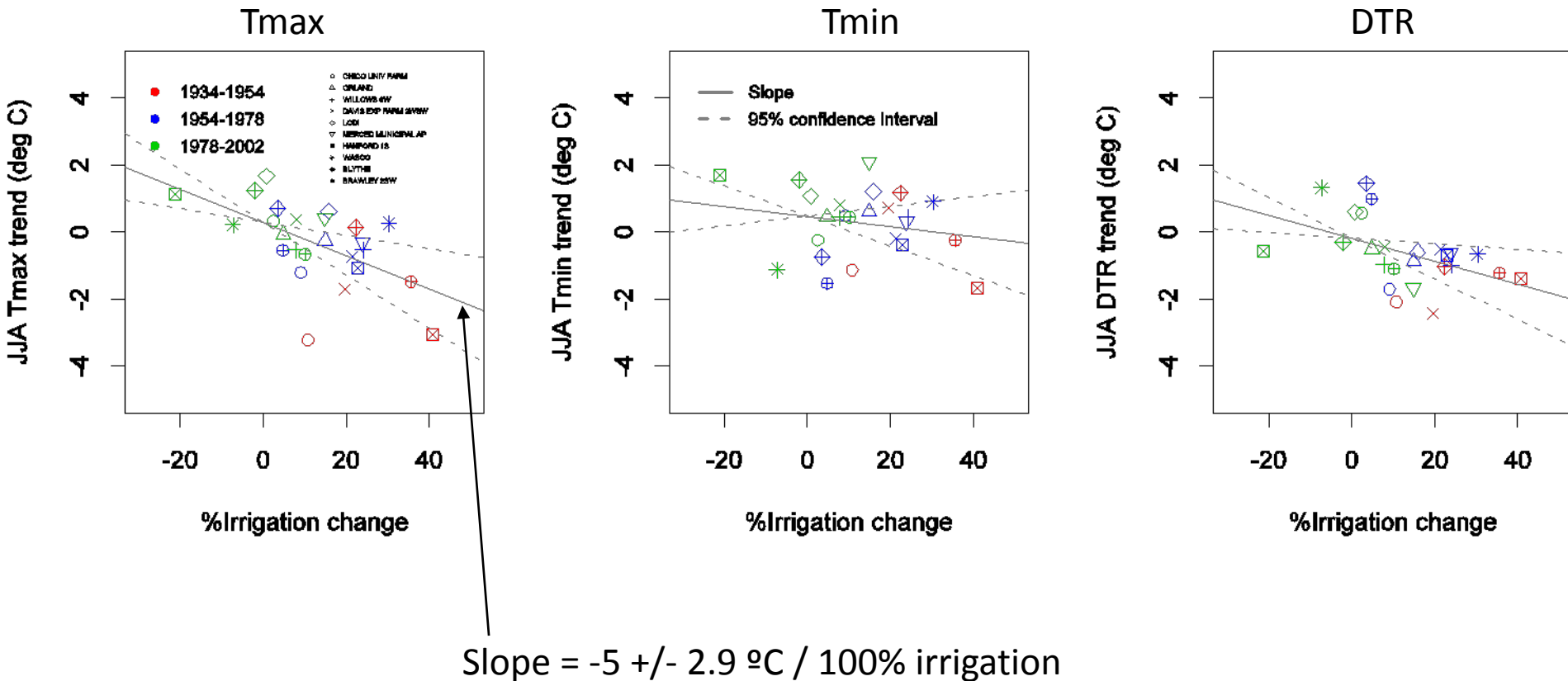


Irrigated area for top 8 counties

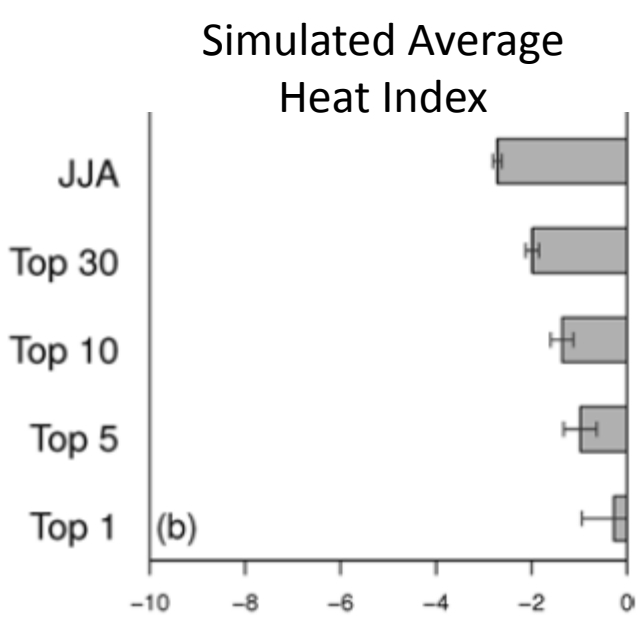
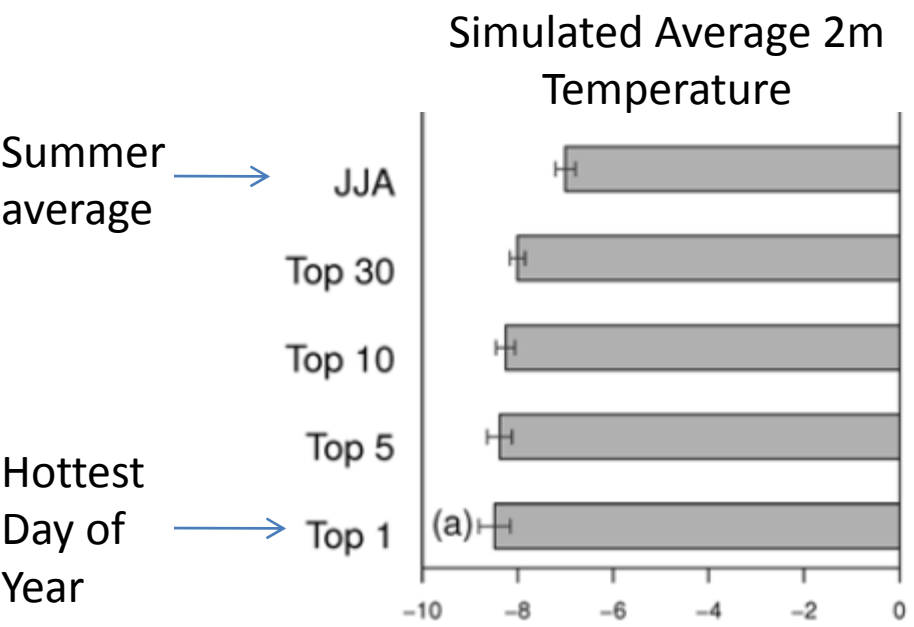
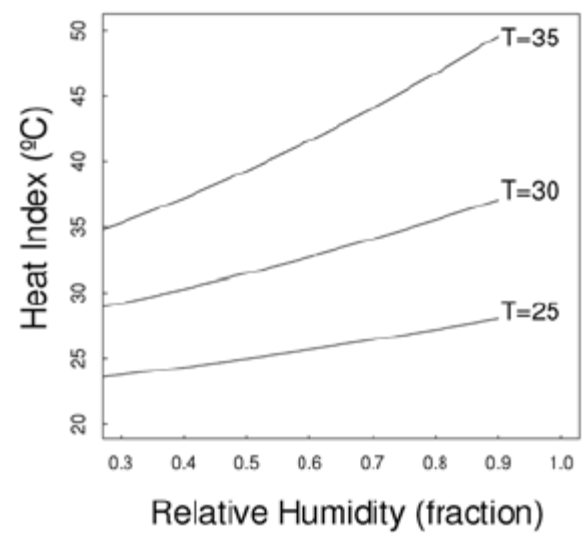


Source: USDA censuses

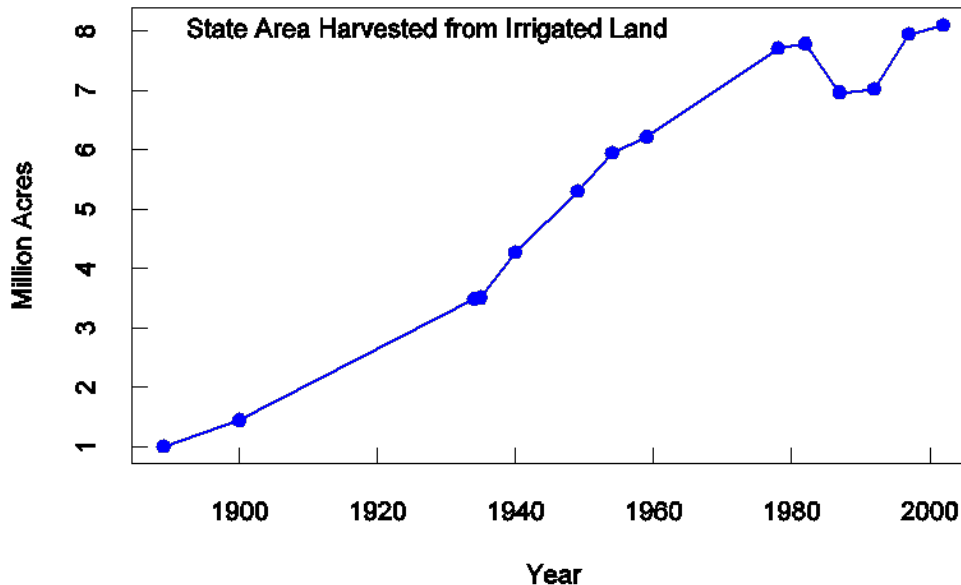
How much has irrigation influenced climate?: observations



Cooling is due to more latent heat flux, which raises humidity.
Therefore, it feels only a little cooler, and just as hot on the hottest days.



Implications for past and future temperatures



The story based on area:

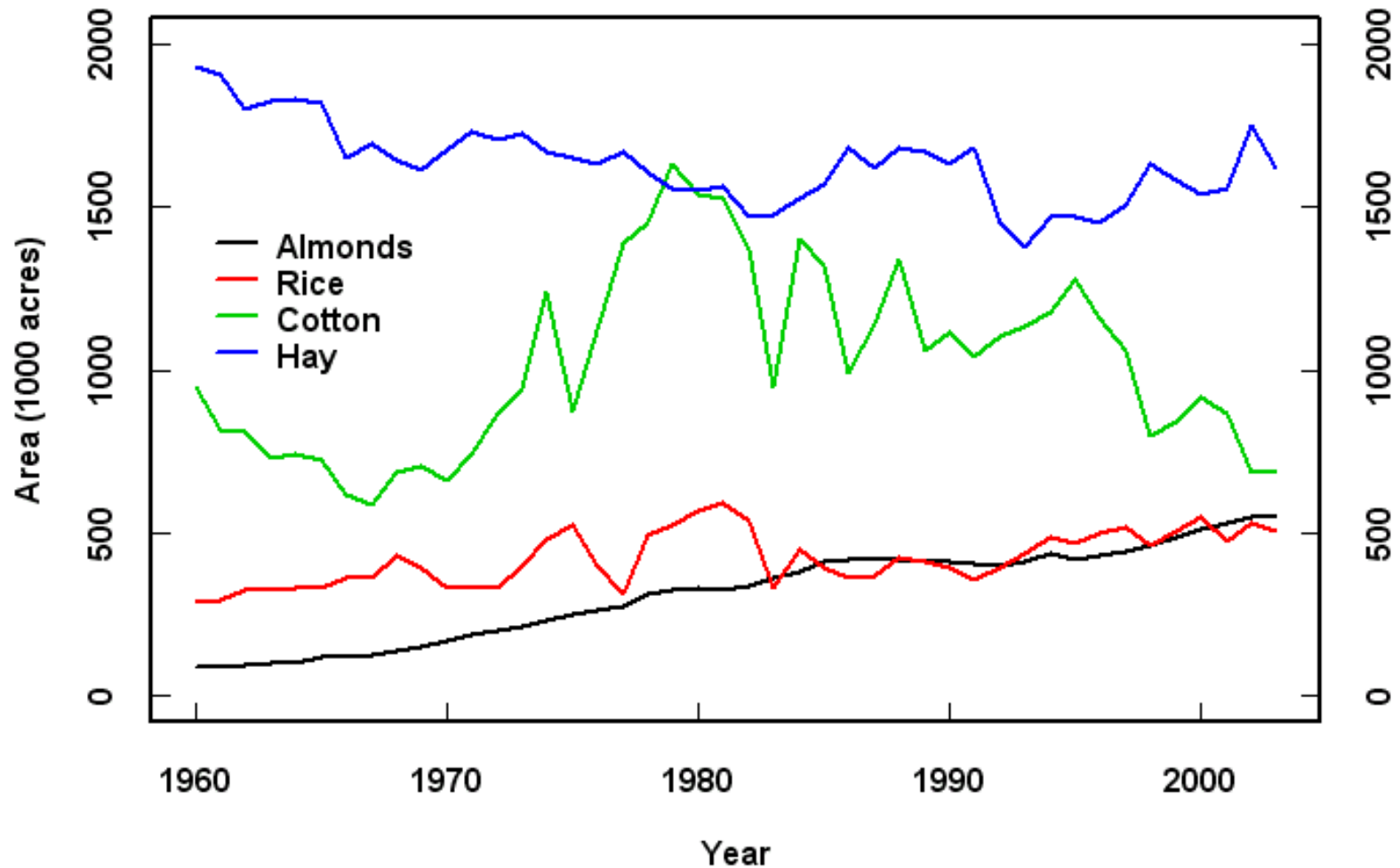
- temperature increases up to 1980 would have been greater without irrigation expansion

- future temperatures are unlikely to see the cooling effect of irrigation expansion

- but area of irrigation is only one factor

Area is constant since ~1980, but mix of crops is changing

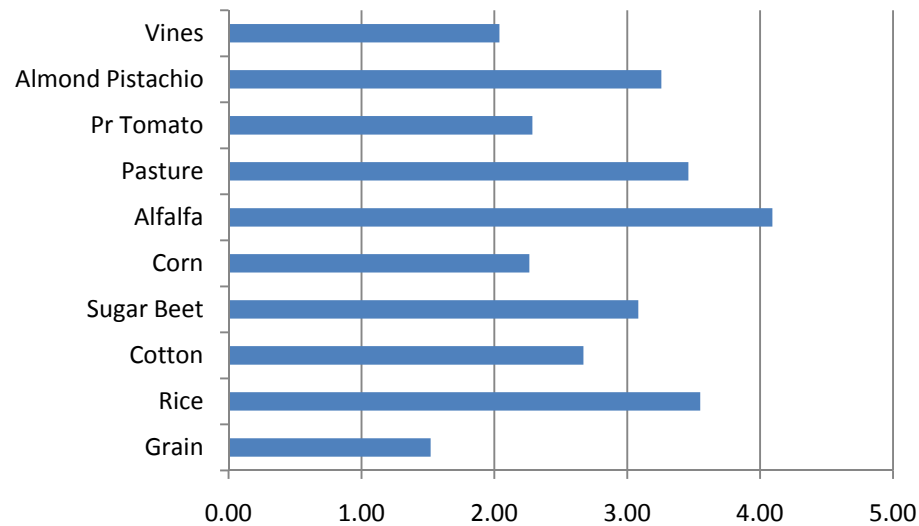
Crop areas in California, 1960-2003



Data Source: USDA

Area is constant since ~1980, but mix of crops is changing

Average ET for crops in California (acre-feet per acre)



Data Source: Dept Water Resources

Irrigation methods are also changing

Figure 6. Comparison of irrigated land by gravity-driven surface irrigation by various crops from 1972, 1980, 1991, and 2001

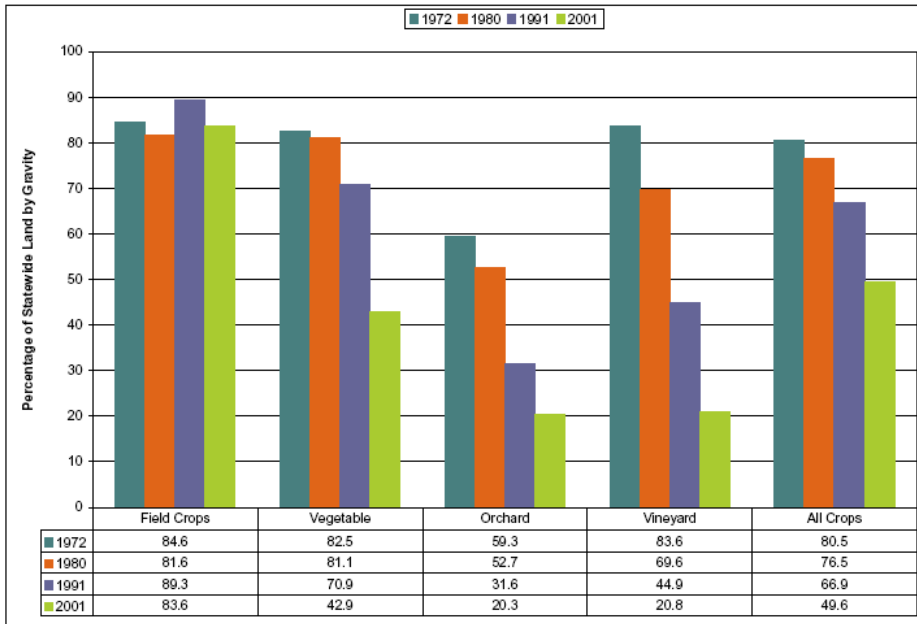
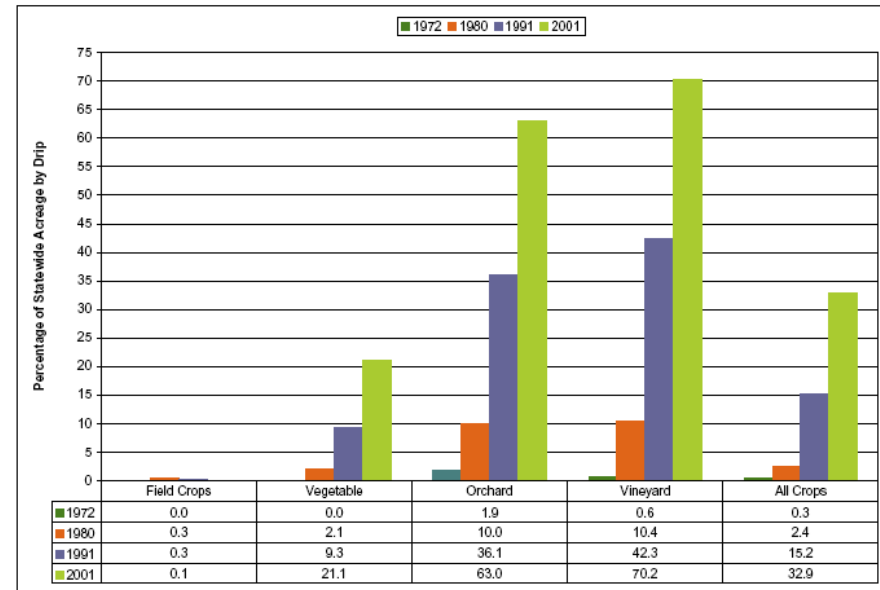


Figure 4. Comparison of irrigated land by micro/drip irrigation by various crops from 1972, 1980, 1991, and 2001



Effect of irrigation method on ET

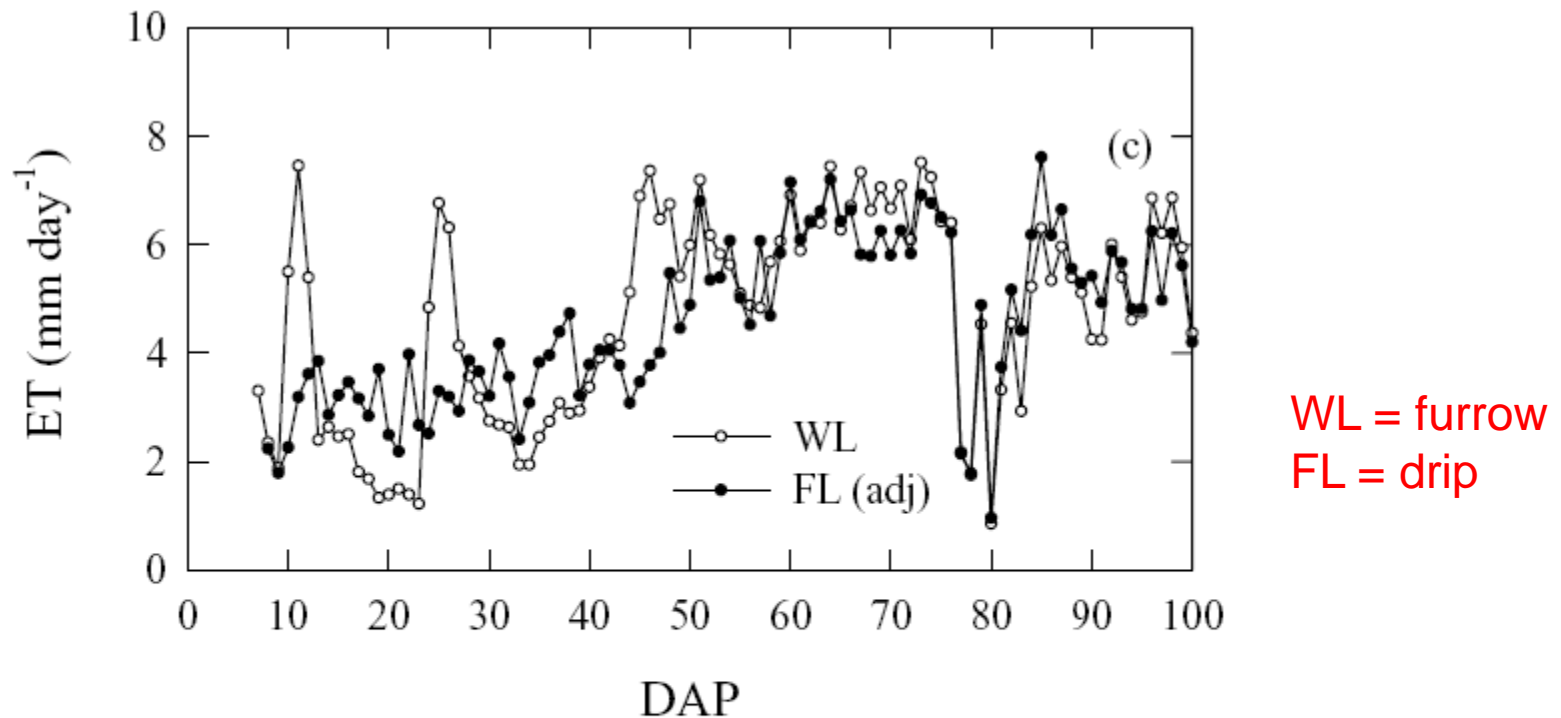


Figure 6. Trend of daily ET, ET_o , canopy cover, and daily crop coefficient (K_c) for cotton under drip irrigation (floating lysimeter-FL) or furrow irrigation (weighing lysimeter-WL). Comparison of crop ET for the two irrigation methods after adjusting for the effect of the lower canopy of the drip irrigated (see *Methods*) is given in (c). Downward triangles indicate the time of furrow irrigation. Planting was on June 13, 2000.

Summary

- Several recent modeling and empirical studies support the hypothesis that irrigation causes cooling of daytime temperatures of up to several degrees.
- Net effects on night-temperatures are much smaller. Studies that attribute night warming to irrigation (Christy et al. 2006) are likely confounded by urbanization
- Summers have been cooled by expanding irrigation in the past (up to 1980), but warming rates for summer are likely to accelerate now that expansion has ceased.
- Changes in crop type and irrigation method may enhance future warming even if irrigated area stays constant
- More model simulations and data will likely improve our understanding, particularly in the effects of crop type and irrigation method